Forest Structure & Lidar Imaging *Resource Brief*

Importance

More than two-thirds of the land in National Capital Region (NCR) national parks is covered by forest. The structure of these forests influences what creatures can live, breed, and feed there. Forest structure is the vertical and horizontal arrangement of plants in a forest, both dead and alive. It includes the height, density (thickness), and "bumpiness" of the tree canopy and understory (beneath the canopy) layers. In general, the more layers in a forest, the more biodiversity.

Many factors go into shaping forest structure including the species present, available light, animal browse, storms, gradual climate change, historic land-use, and soil nutrients. We are accustomed to observing forest structure from the ground but what if we could observe the three-dimensional structure from above?

Monitoring

Throughout the NCR, the National Capital Region Network Inventory & Monitoring (NCRN I&M) program monitors forest habitat from the ground at designated forest plots. But to capture information on the three-dimensional structure of the forest, the NCRN arranged for collection of lidar (light detection and ranging) data at Catoctin (CATO), Harpers Ferry (HAFE), a portion of the C&O Canal (CHOH) in the vicinity of Harpers Ferry, and Prince William Forest (PRWI). Lidar is a type of remote imaging that measures the height of objects on the ground. It uses a special plane-mounted laser that sends down pulses of light. Objects above the ground, or the ground itself, reflect the pulses, called "returns," back up to a sensor. The height of objects can then be determined based on how long it takes the returns to arrive back at the airplane. When lidar is flown over a forest, the returns are used to create a 3-dimensional image of the forest from the top of the tree canopy to the ground.

Collection flights were flown on August 7, 2009 at PRWI and on July 27, 2010 at CATO, CHOH, and HAFE. To get an accurate understanding of the canopy structure, data were gathered in the summer during "leaf-on" conditions.

Results

Using the raw lidar data, NCRN I&M produced data sets (layers) for each park on the following:

- Ground or "bare earth" elevation, also called a digital elevation model (DEM)
- Canopy height (height of the top of the tree canopy)
- Canopy cover (percent area of canopy above 3m)
- Forest gaps (areas where the tallest vegetation is less than 3m tall)
- Percentage of understory vegetation (percent of returns between the ground and 3m)

After collecting lidar data, a 2m resolution digital elevation model of the ground surface was created and used in the processing of subsequent data products. The elevation layer provides some of the highest resolution elevation data currently available to the parks.

We also created a detailed picture of canopy height (1m and 2m resolutions) that reveals how canopy height varies inversely with elevation—trees are taller in valleys and shorter on ridges (Figure 1). The most common canopy height for all parks ranged from 25-30 meters (equivalent to a 5- to 6-story building). The tallest trees ranged from 45-47 meters (10 stories!).

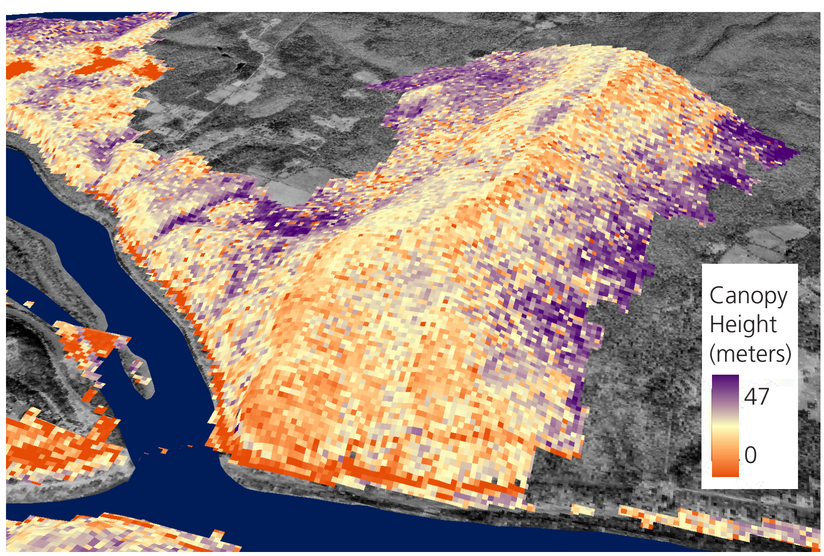

Image: NPS/Lehman

Figure 1. Looking north across the Potomac River at Maryland Heights in Harper's Ferry, shorter trees (orange) define the ridge line and waters edge, and taller trees (purple) cover the lower slopes.

Looking at canopy layers revealed that forest cover is relatively dense and continuous. There were some canopy gaps, but most were small (<20m^2) and likely caused by the death of a single tree. Larger gaps were often correlated with streams, while one large gap area in PRWI was the result of a forest fire (Figure 2).

Understory vegetation, the layer below 3m high and above the ground surface, was difficult to detect due to the dense leaf-cover of the canopy. At PRWI, lidar returns from the understory were detectable in 52% of the park, and in that area, understory cover averaged 68%. Tighter flight lines were flown at CATO, CHOH, and HAFE in an effort to increase returns from the understory and as a result, the understory was detectable in about 68% of the park area, showing an average understory cover at CATO of 73.9%, and at HAFE and CHOH of 84%.

While the forest structure data produced so far are very interesting on their own, they will be much more useful when used in conjunction with other data sets. NCRN I&M hopes to eventually look for correlations between forest structure and our monitoring data on forest birds, forest vegetation, and amphibians. These data can also be used to evaluate how past land management practices have impacted the vegetation structure of the forests which will hopefully lead to improved management decisions.

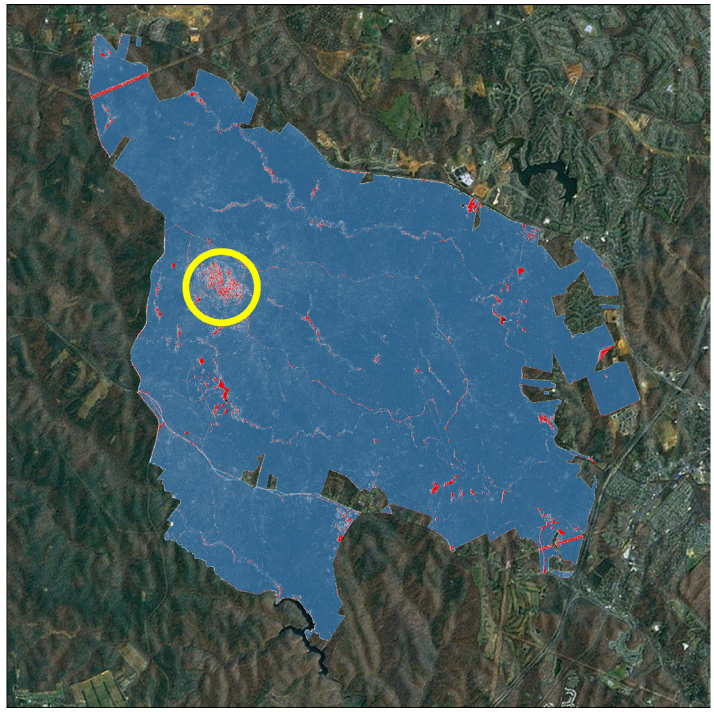

Figure 2. At Prince William Forest Park, an area of lower elevation vegetation (red) creates a gap in the taller forest canopy (blue). This gap is the result of a small forest fire.

More information on this project and related data products is available at https://irma.nps.gov/App/Reference/Profile/2197952.

References:

Elmore, A.J., S.M. Guinn, and G. Sanders. 2013. Vegetation structure within the National Capital Region Network using LiDAR data and analysis: Prince William Forest Park, Catoctin Mountain Park, C&O Canal National Historical Park, and Harpers Ferry National Historical Park. Natural Resource Data Serices NPS/NCRN/NRDS—2013/475. National Park Service, Fort Collins, Colorado.

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